

Figure 4.27 CASE 1, Latitude 40°, Interference Event Duration, Mobile Earth Station .

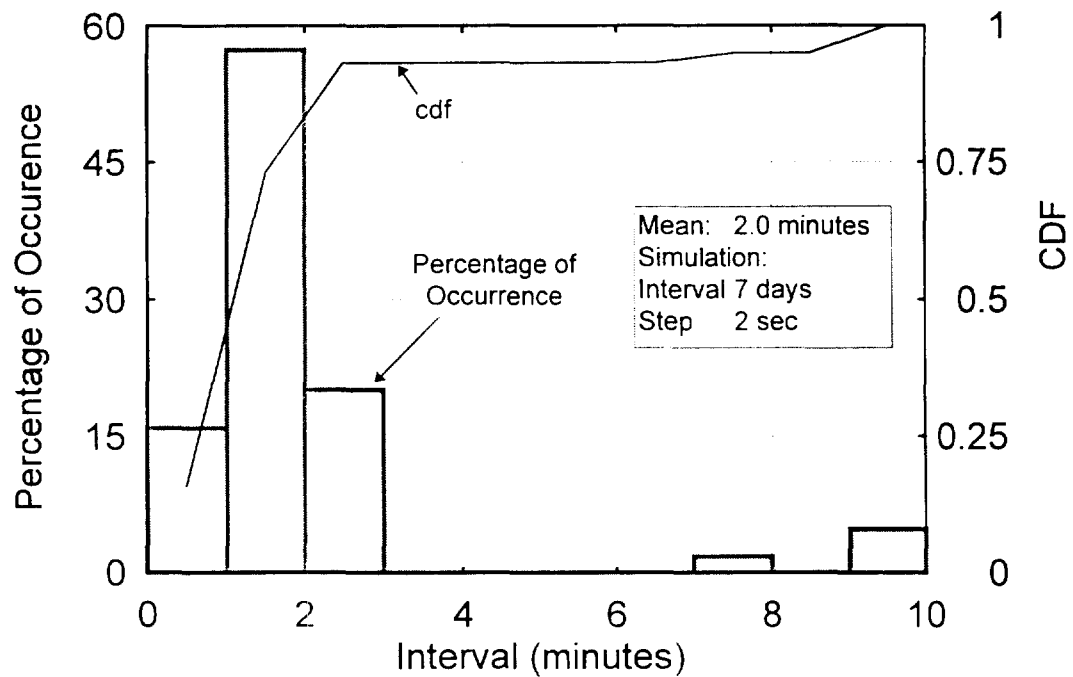


Figure 4.28 CASE 1, Latitude 40°, Interval Between Interference Events, Mobile Earth Station .

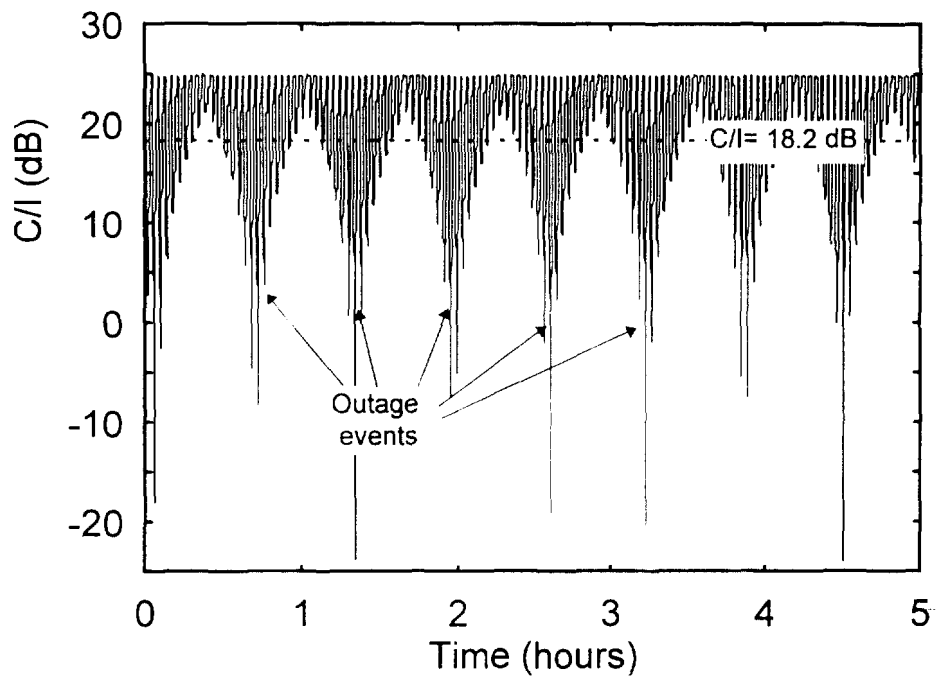


Figure 4.29 CASE 1, Latitude 25°, C/I Time History, Mobile Earth Station .

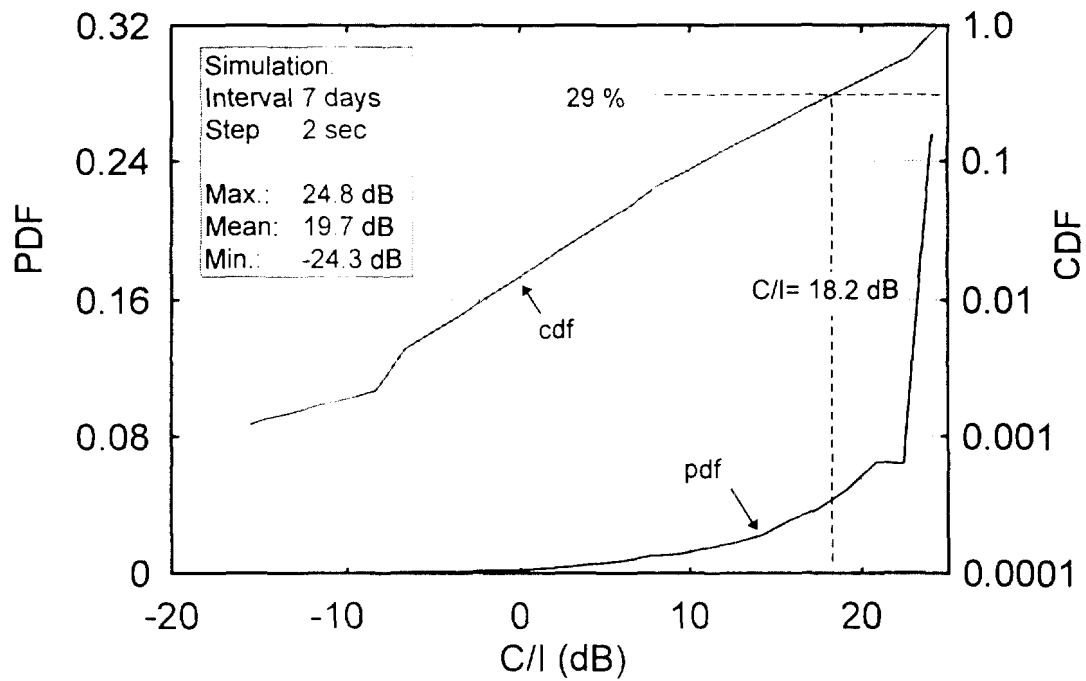


Figure 4.30 CASE 1, Latitude 25°, C/I Probability, Mobile Earth Station .

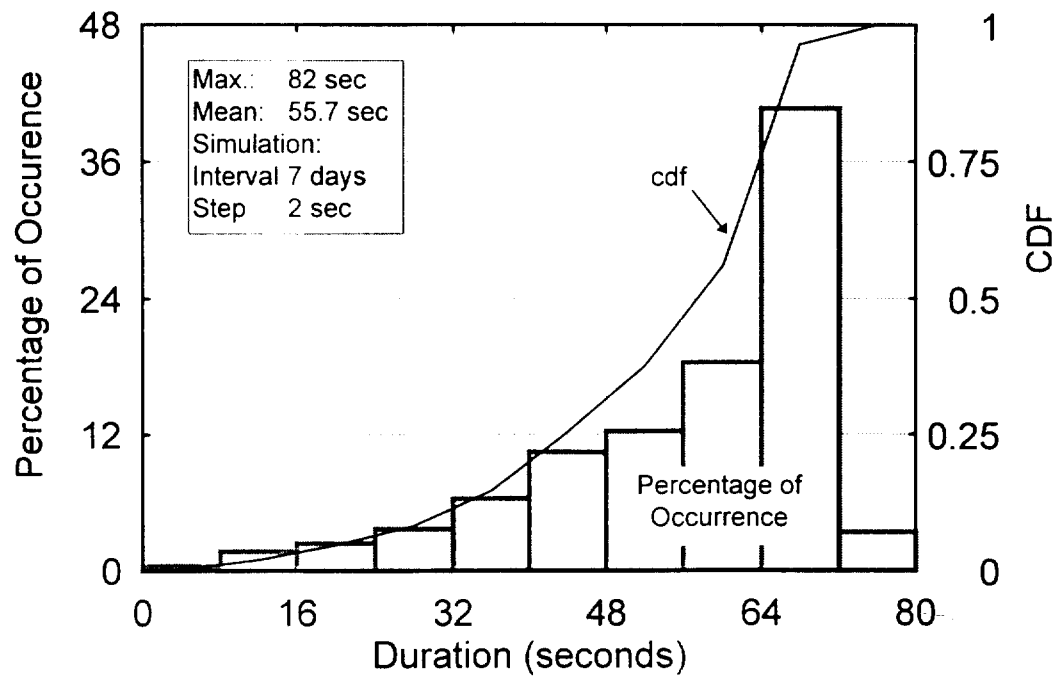


Figure 4.31 CASE 1, Latitude 25°, Interference Event Duration, Mobile Earth Station .

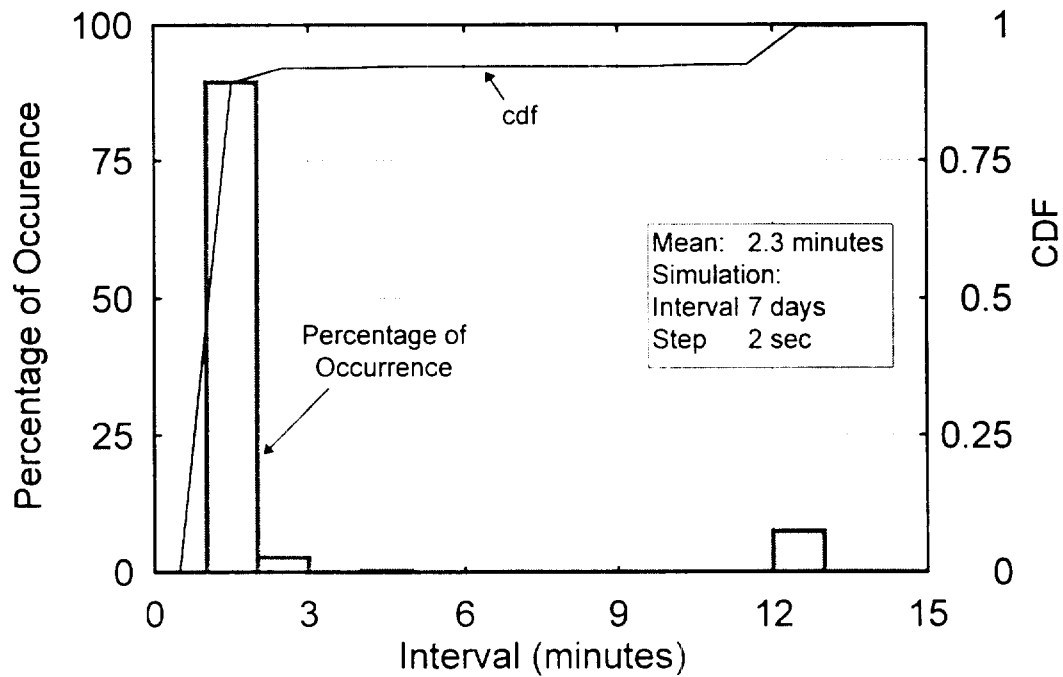


Figure 4.32 CASE 1, Latitude 25°, Interval Between Interference Events, Mobile Earth Station .

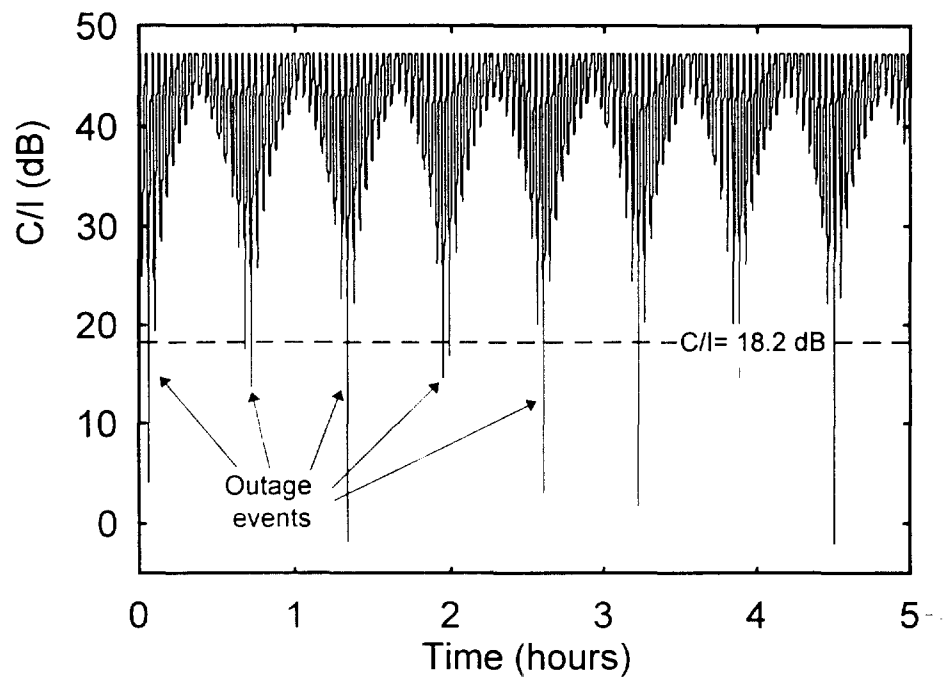


Figure 4.33 CASE 1, Latitude 25°, C/I Time History, High-rate Earth Station .

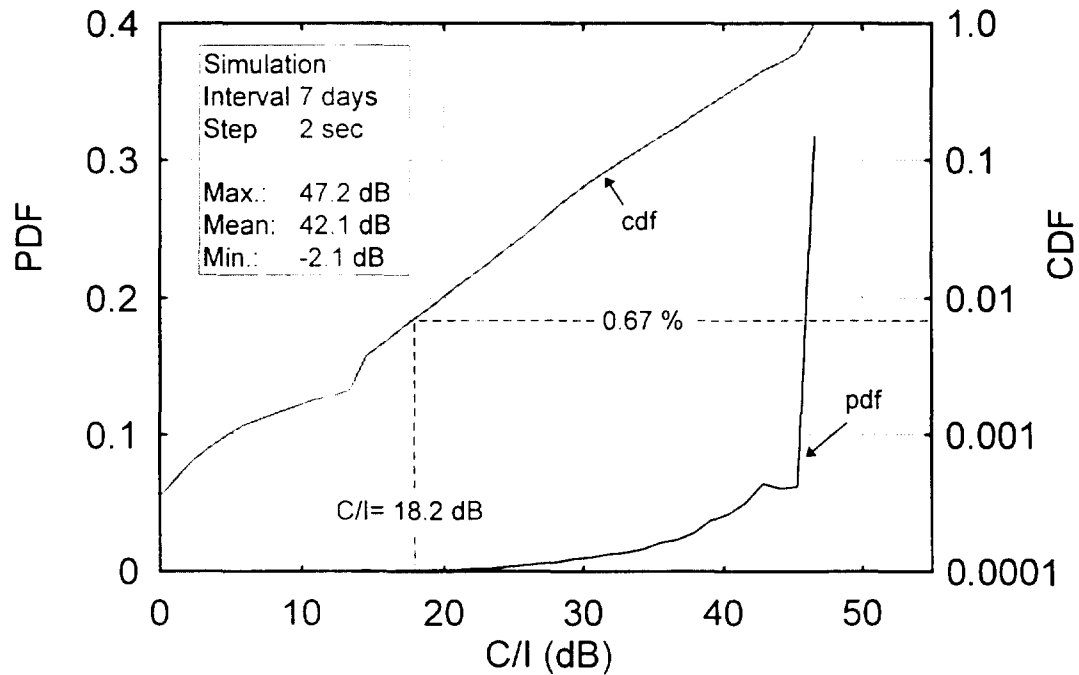


Figure 4.34 CASE 1, Latitude 25°, C/I Probability High-rate Earth Station .

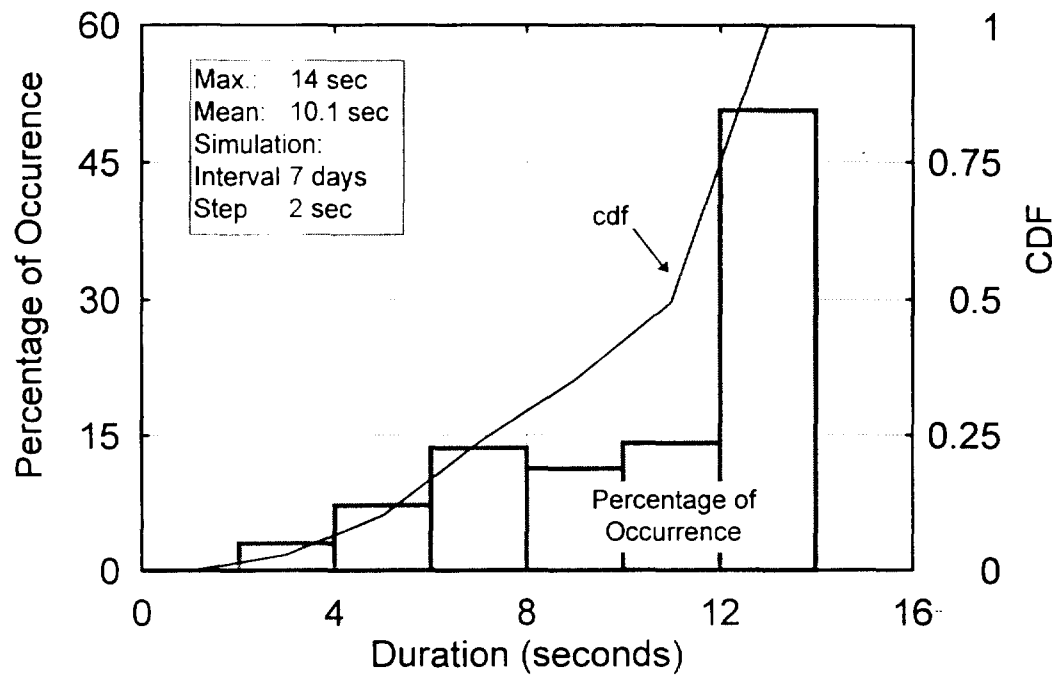


Figure 4.35 CASE 1, Latitude 25°, Interference Event Duration High-rate Earth Station .

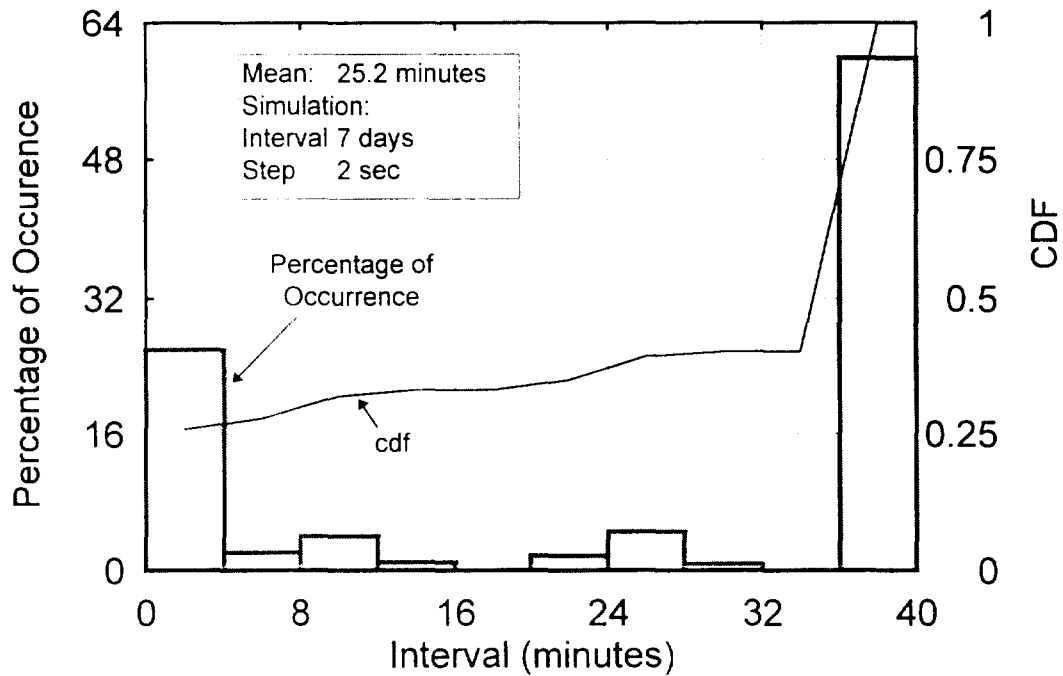


Figure 4.36 CASE 1, Latitude 25°, Interval Between Interference Events High-rate Earth Station .

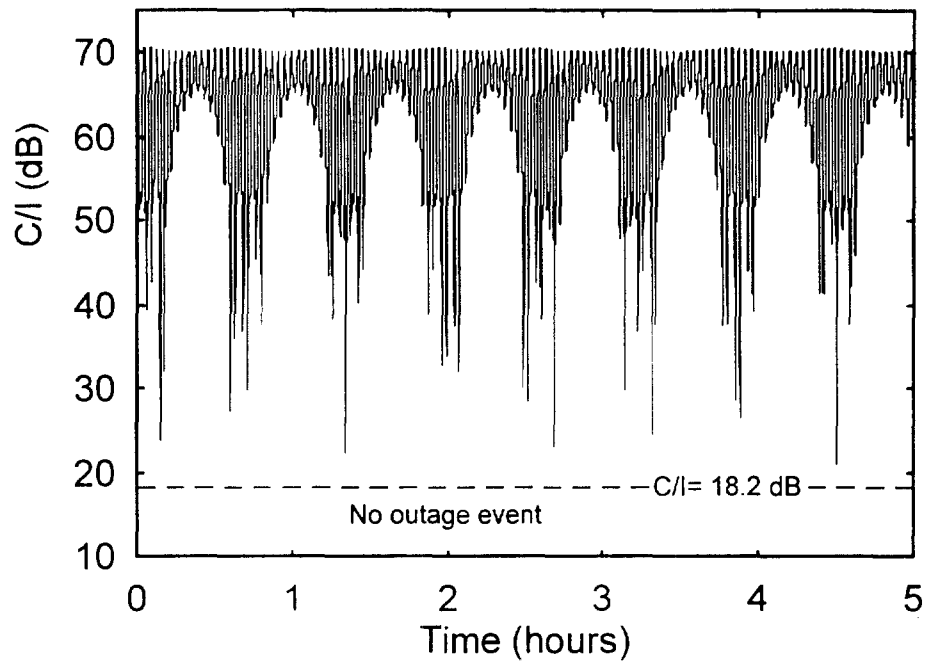


Figure 4.37 CASE 2, Latitude 25°, C/I Time History High-rate Earth Station .

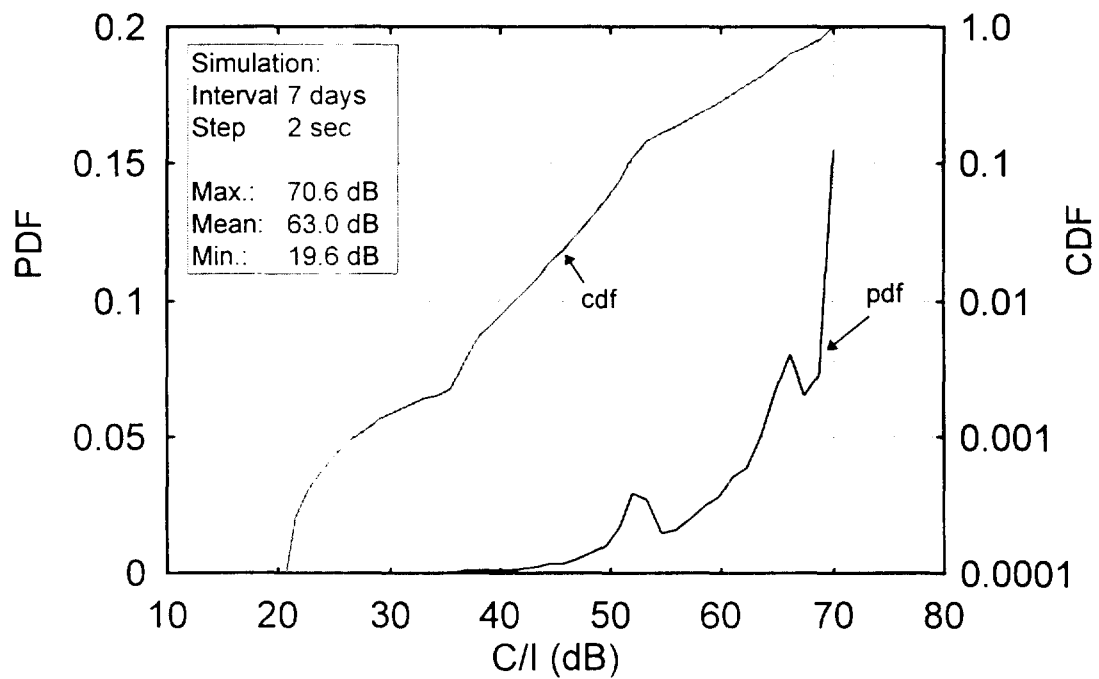


Figure 4.38 CASE 2, Latitude 25°, C/I Probability High-rate Earth Station .

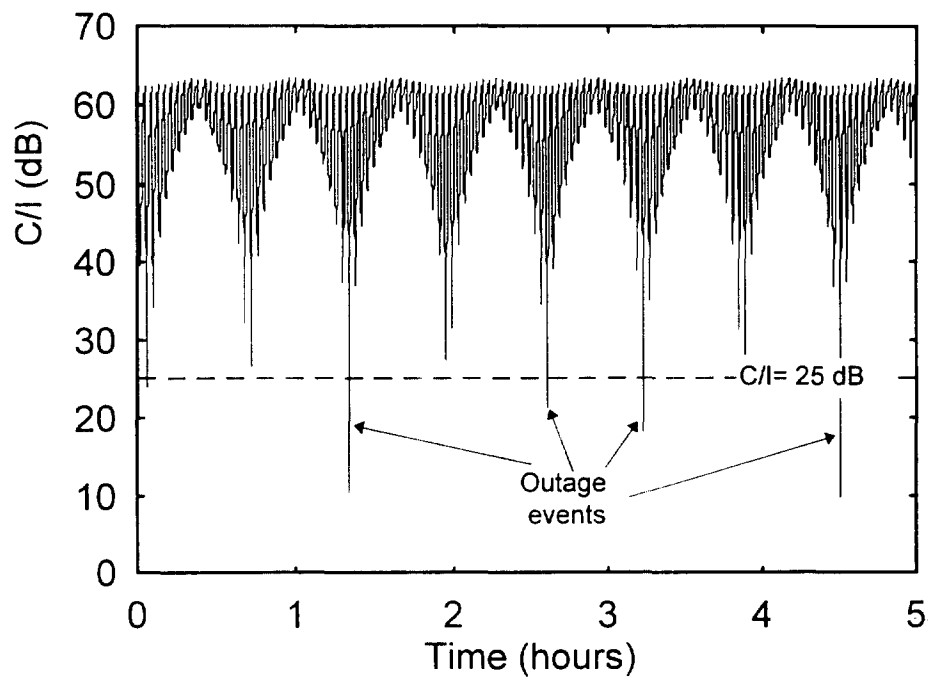


Figure 4.39 CASE 3, Latitude 25°, C/I Time History High-rate Earth Station .

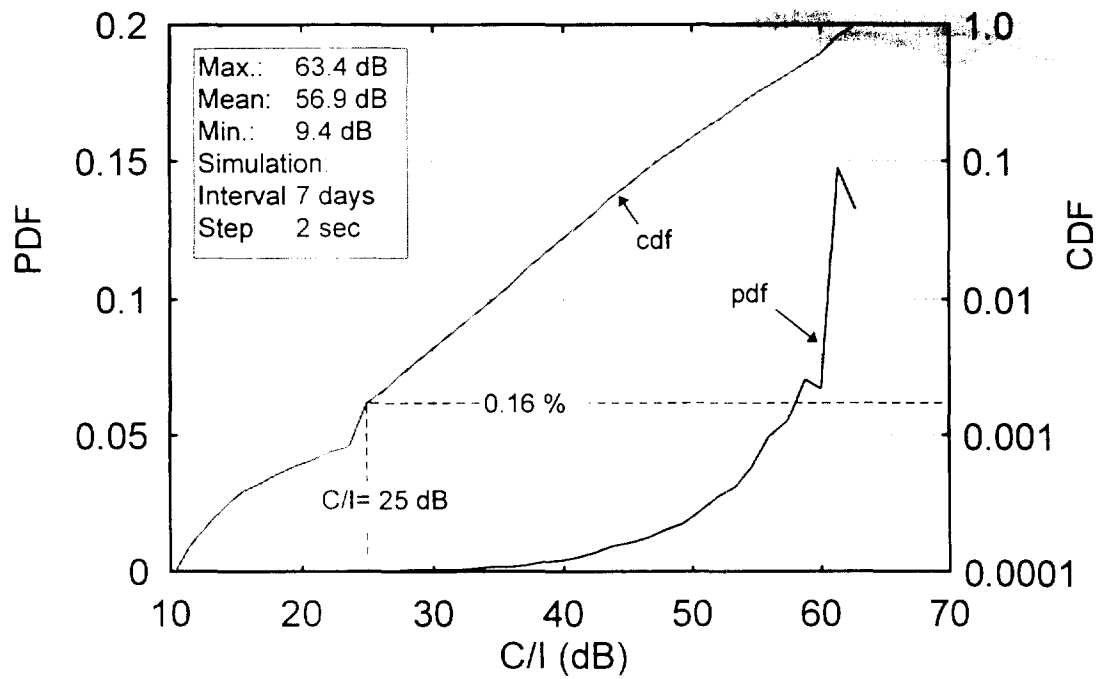


Figure 4.40 CASE 3, Latitude 25°, C/I Probability High-rate Earth Station .

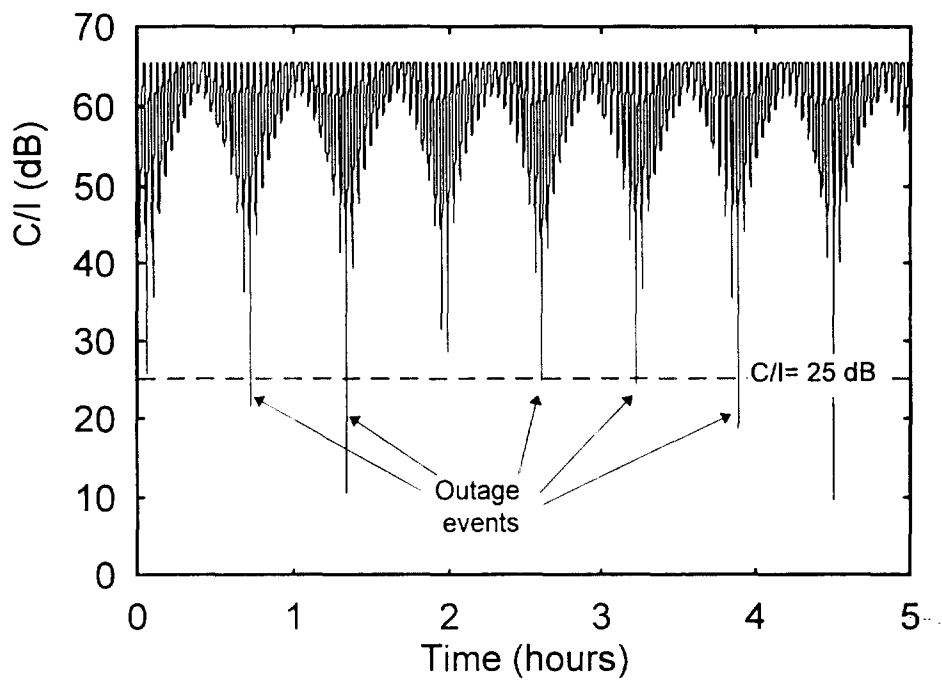


Figure 4.41 CASE 4, Latitude 25°, C/I Time History High-rate Earth Station .

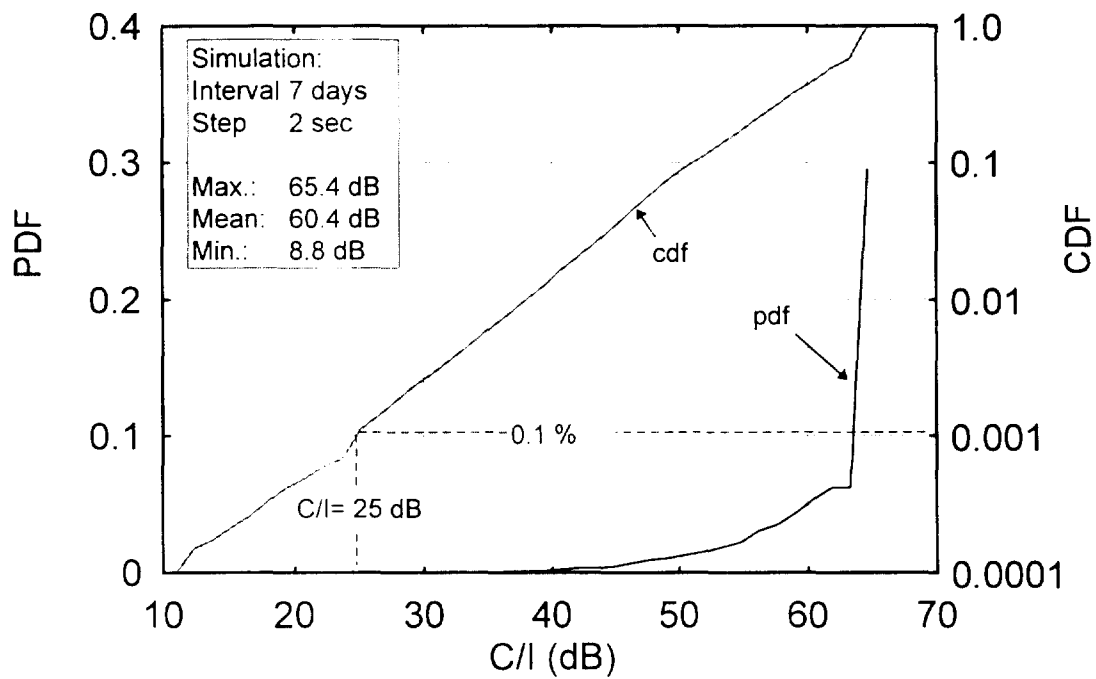


Figure 4.42 CASE 4, Latitude 25°, C/I Probability High-rate Earth Station .

APPENDIX D

Spectrum Use by the LEO-SAT-1 Network

1. Introduction

This paper describes the spectrum use by a low-Earth-orbit satellite network that is proposed to provide communications in the mobile satellite service (MSS) and the fixed satellite service (FSS) in the frequency bands 27.5 to 30.0 GHz and 17.7 to 20.2 GHz. Designated as LEO-SAT-1, the network also proposes to use intersatellite links near 60 GHz. However, use of the intersatellite service frequency bands is not discussed in this paper.

The proposed network incorporates both MSS and FSS earth stations. At times, the FSS earth stations are used to provide MSS feeder links within the network. This discussion of spectrum use is framed within the present context of the Radio Regulations where the distinction is made between service types, such as MSS and FSS. This distinction is not inherent in the nature of the communication services provided by the LEO-SAT-1 network. More critical, perhaps, is the distinction between system types, such as GSO and NGSO, because this difference is crucial to the evaluation of frequency sharing possibilities between systems. The LEO-SAT-1 network incorporates NGSO satellites, and the spectrum use is described as NGSO FSS, NGSO MSS, and NGSO MSS feeder links, using the present distinctions between MSS and FSS and the designated use of FSS for MSS feeder links.

2. Spectrum Use by the LEO-SAT-1 Network

2.1 Network Description

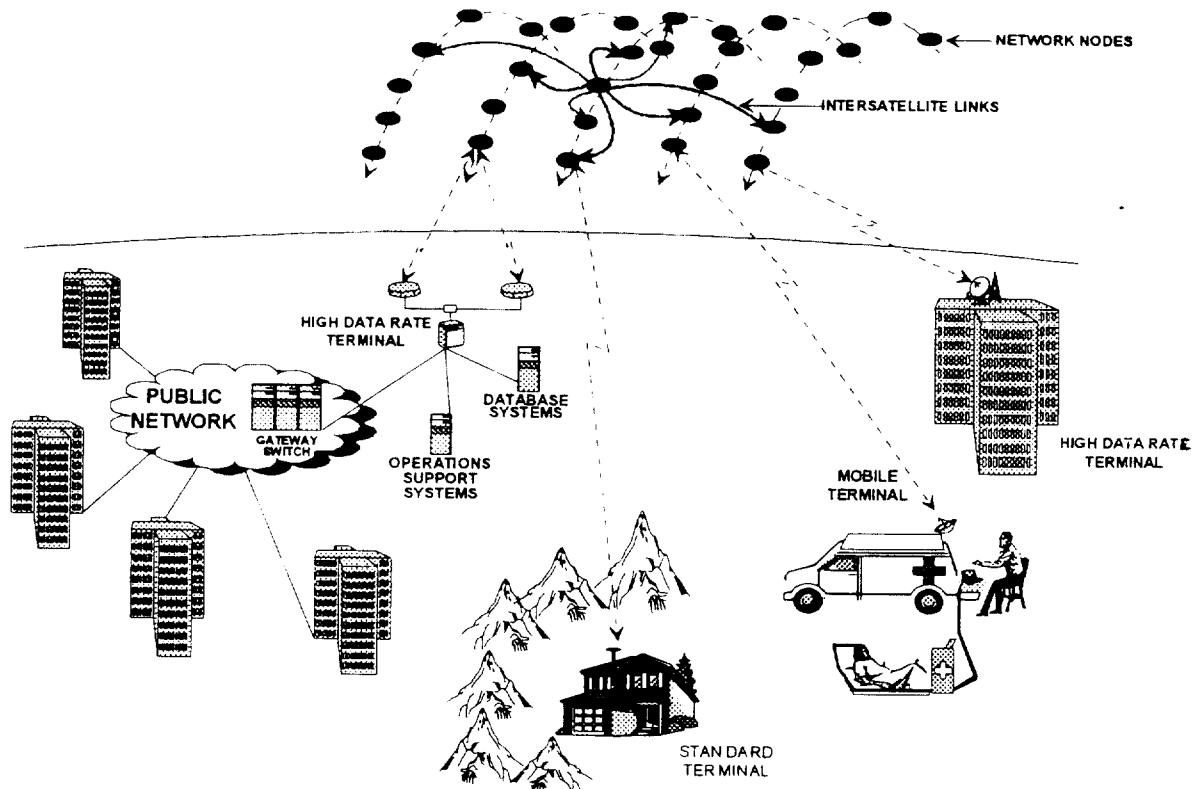
The proposed network uses a constellation of 840 operational interlinked low-Earth-orbit satellites to provide global access to a broad range of voice, data and video communication capabilities. The network will provide switched digital connections between users of the network through a variety of terminals with transmission rates from 16 kbps to 1.24416 Gbps.

The satellite constellation is organized into 21 circular orbit planes that are staggered in altitude between 695 and 705 km. Each plane contains a minimum of 40 operational satellites plus up to four on-orbit spares spaced evenly around the orbit. The orbit planes are at a sun-synchronous inclination (approximately 98.2 degrees).

The satellite constellation is designed to ensure that there is always at least one satellite visible above a 40 degree elevation angle over the entire coverage area.

Network connections are shown pictorially in Figure 1. Connections to other communications networks are made via the high-data-rate terminals. The standard terminals and the high-data-rate terminals support FSS service and MSS feeder links. The mobile terminals support MSS applications, with the standard terminals and the high-data-rate terminals providing the required MSS feeder links.

Figure 1. The LEO-SAT-1 Communication Network



2.2 Details of Spectrum Use

The specific frequencies proposed for LEO-SAT-1 use are given in table 1. The need for separate frequencies to accommodate fixed and mobile applications is not inherent in the LEO-SAT-1 network. The same digital broadband capability could be provided to both fixed and mobile applications using the same frequencies through the same terminals. The use of separate bands for FSS and MSS is required to conform with the service distinctions made in current Radio Regulations. Accordingly, two band segments in each direction are needed for the standard terminals and the high-data-rate terminals. The mobile terminals require a single, smaller sub-band in each direction.

The intra-network connections are shown in figures 2a and 2b. Transmission paths are shown connecting MSS and FSS terminals. Depending on the terminal used and the message destination, the transmissions are either MSS, FSS, or MSS feeder links. Details of band use for specific transmission paths are given in table 2. The table shows that the same frequencies are used for both FSS service link transmissions and MSS feeder link transmissions, but at different times. At any instant of time, the

spectrum use by both the standard terminals and the high data rate terminals is a mixture of FSS and MSS feeder link use that depends upon the instantaneous traffic mix.

Thus, the spectrum requirements for the LEO-SAT-I network include the frequency bands used for MSS service links and the other frequency bands used for both FSS service links and for MSS feeder links on a time shared basis. Coordination and interference mitigation techniques would be used to share frequencies with other users of the bands.

Table 1. Frequency Bands, Requested Frequencies, and Total Bandwidth

| | Frequency Band | Requested Frequencies | Total Requested Bandwidth |
|---|-----------------------------------|-----------------------------------|----------------------------------|
| Standard Terminal Uplink | 27.5 - 30.0 GHz | 28.6 - 29.0 GHz | 400 MHz |
| Standard Terminal Downlink | 17.8 - 18.6 GHz & 18.8 - 20.2 GHz | 18.8 - 19.2 GHz | 400 MHz |
| Mobile Terminal Uplink* | 29.5 - 30.0 GHz | 29.5 - 29.6 GHz | 100 MHz |
| Mobile Terminal Downlink* | 19.7 - 20.2 GHz | 19.7 - 19.8 GHz | 100 MHz |
| High-Data-Rate & Command Uplink | 27.5 - 30.0 GHz | 27.6 - 28.4 GHz | 800 MHz |
| High-Data-Rate Downlink & Telemetry Downlink | 17.8 - 18.6 GHz & 18.8 - 20.2 GHz | 17.8 - 18.6 GHz | 800 MHz |
| ISL | 59 - 64 GHz | 59.5 - 60.5 GHz & 62.5 - 63.5 GHz | 2000 MHz |

* Mobile satellite service currently not proposed for the United States

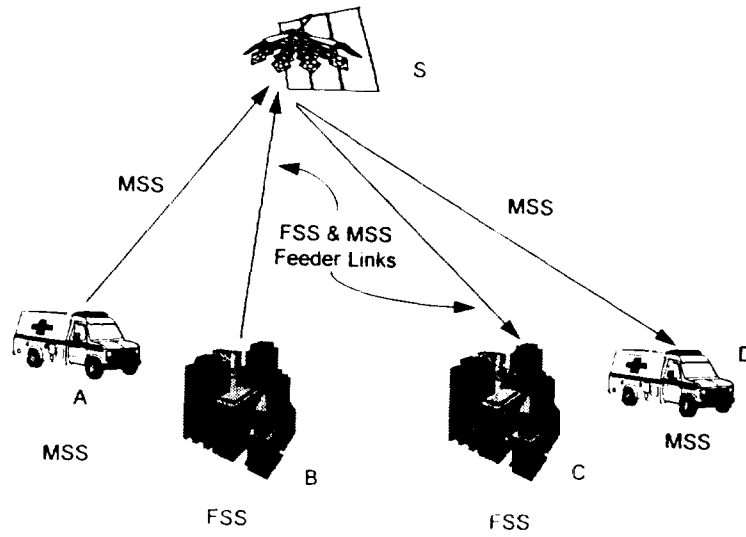


Figure 2a. Network Connections, Forward Path

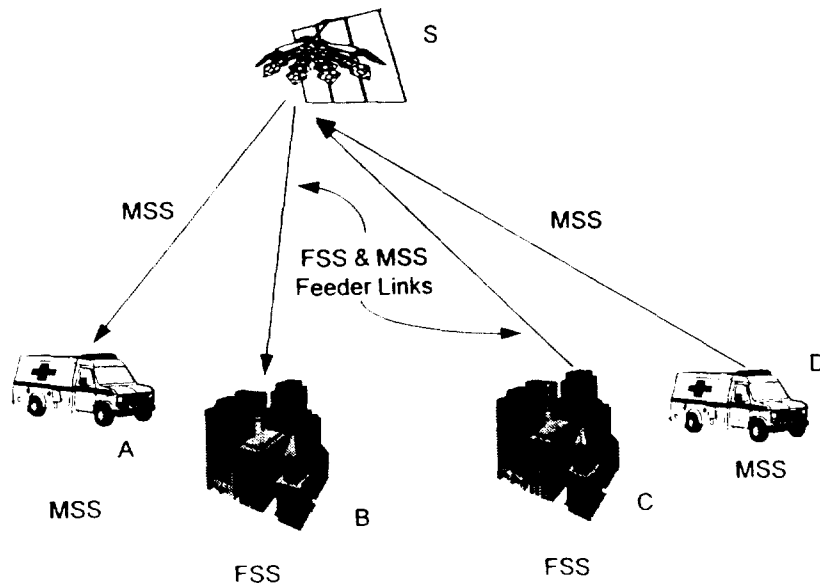


Figure 2b. Network Connections, Return Path

Table 2. Spectrum Use by LEO-SAT-1 for Typical Network Connections

| <u>MESSAGE PATH</u> | <u>DIRECTION</u> | <u>TERMINAL CONNECTION</u> | <u>BAND USE Earth-Space</u> | <u>BAND USE Space-Earth</u> |
|---------------------|------------------|----------------------------|--|--|
| A-D | Forward | MSS-MSS | A-S/MSS 29.5-29.6 GHz | S-D/MSS 19.7-19.8 GHz |
| D-A | Return | MSS-MSS | D-S/MSS 29.5-29.6 GHz | S-A/MSS 19.7-19.8GHz |
| A-C | Forward | MSS-FSS | A-S/MSS 29.5-29.6 GHz | S-C/MSS F.L. 18.8-19.2GHz or 17.8-18.6GHz |
| C-A | Return | FSS-MSS | C-S/MSS F.L. 28.6-29.0 GHz or 27.6-28.4 GHz | S-A/MSS 19.7-19.8 GHz |
| B-C | Forward | FSS-FSS | B-S/FSS 28.6-29.0 GHz or 27.6-28.4 GHz | S-C/FSS 18.8-19.2 GHz or 17.8-18.6 GHz |
| C-B | Return | FSS-FSS | C-S/FSS 28.6-29.0 GHz or 27.6-28.4 GHz | S-C/FSS 18.8-19.2 GHz or 17.8-18.6 GHz |
| B-D | Forward | FSS-MSS | B-S/MSS F.L. 28.6-29.0 GHz or 27.6-28.4 GHz | S-D/MSS 19.7-19.8 GHz |
| D-B | Return | MSS-FSS | D-S/MSS 29.5-29.6 GHz | S-B/MSS F.L. 18.8-19.2 GHz or 17.8-18.6 GHz |

3. Summary

The proposed LEO-SAT-1 network will provide both MSS and FSS communications. The required intra-network connections result in frequency use for MSS feeder links in both earth-space and space-earth directions. The required spectrum use is shown in table 3 as NGSO FSS, NGSO MSS, and NGSO MSS feeder links. The sub-bands that are shown for both FSS service links and MSS feeder links are time shared between the two uses. The spectrum required by LEO-SAT-1 would be shared with other users via coordination and interference mitigation techniques. If a General Satellite Services (GSS) were to be authorized in these frequency bands, all LEO-SAT-1 spectrum use would be NGSO GSS.

Table 3. Summary of Spectrum Use by LEO-SAT-1

| <u>Frequency GHz</u> | <u>Direction</u> | <u>Use</u> |
|----------------------|------------------|----------------------------------|
| 17.8-18.6 | Space-Earth | NGSO FSS and MSS Feeder Links |
| 18.8-19.2 | Space-Earth | NGSO FSS and MSS Feeder Links |
| 19.7-19.8 | Space-Earth | NGSO MSS |
| 27.6-28.4 | Earth-Space | NGSO FSS and MSS Feeder Links |
| 28.6-29.0 | Earth-Space | NGSO FSS and MSS Feeder Links |
| 29.5-29.6 | Earth-Space | NGSO MSS |